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Diode-Pumped Solid State Laser Systems: Multi-kilowatts to Megawatts

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ABSTRACT

In recent years, diode pumped Nd:YAG solid state lasers (DPSSLs) have been demonstrated at the kilowatt average power level in laboratory devices, and can be purchased commercially at the multi hundred watt power level. Other laser ions, such as thulium, (Tm) and ytterbium (Yb) have also recently been used in YAG DPSSLs to generate in excess of a hundred watts of average power. Power scaling of Yb-based DPSSLs into the kilowatt power range is under way. The power generating gain elements in these lasers take the form of either cylindrical rods or rectangular parallelepiped slabs, cooled by liquid flowed over the larger lateral surfaces of the gain element. Analysis suggests that scaling the average power of DPSSLs with these power generating gain elements and cooling architectures (while retaining high beam brightness) is limited to a few kilowatts per aperture, at most. To scale DPSSL average power per unit aperture well beyond the multi-kilowatt power level (into the >hundred-kilowatt power regime) calls for the conceptualization and development of novel laser system architectures and implementing components (pump arrays, pump radiation transport optics, gain elements, cooling subsystems, cavity or extraction configurations, and mode control strategies). Technically plausible power scaling architectures and implementing components will also likely depend on the principal spectroscopic and bulk properties of the laser gain medium (e.g., three, or four level laser ion scheme; demand pump brightness and deposited pump power density, in relation to thermally induced index of refraction gradients). This paper will examine some DPSSLs architectures that accommodate and balance the suite of spectroscopic, thermal, optical, and mechanical constraints of major components and subsystems relevant to DPSSLs with output powers per aperture >10's of kW.

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